San Juan- Carolina BRT Study

Operations Planning Memorandum

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1. INTRODUCTION

1.1 Study Overview

The San Juan – Carolina Bus Rapid Transit (BRT) study is examining the feasibility of a planned BRT service along an eight mile corridor stretching from the Rio Piedras Tren Urbano Station in San Juan to the Roberto Clemente Walker Stadium in Carolina, Puerto Rico.

1.2 Report Overview

This report summarizes the methodology, assumptions and results of the operations planning process undertaken by Jacobs Engineering to advance the analysis of the proposed BRT service. The report first identifies the proposed routes, outlines information sources, and identifies assumptions made for the purposes of developing a conceptual service schedule. The report then includes a summary of the methodology used for the development of vehicle running times and schedules. This is followed by results of the service planning effort and estimates of operating and maintenance costs for the service.

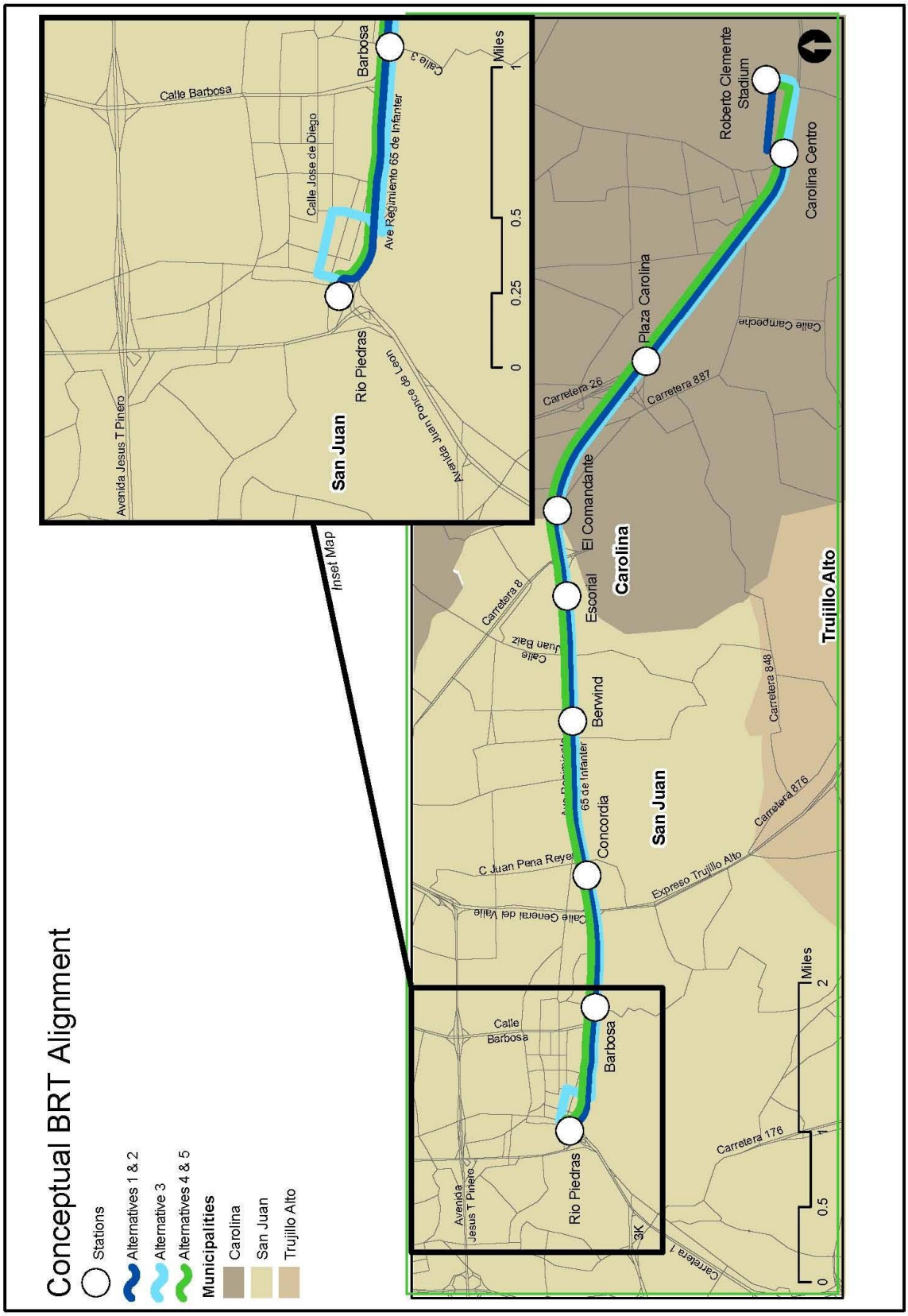
2. ROUTE DEFINITION

The operations planning effort included the analysis of four primary route alternatives and two general service options. The alternatives examined are as follows:

- Alternative 1 – PR-3 Busway with Rio Grande Loiza bridge southern alignment and south Rio Piedras Station location
- Alternative 2 – PR-3 Busway with Rio Grande Loiza bridge northern alignment and south Rio Piedras Station location
- Alternative 3 – PR-3 Busway with Rio Grande Loiza bridge mixed traffic alignment and Tren Urbano Rio Piedras Station location
- Alternative 4 – PR-3 Busway with Rio Grande Loiza bridge mixed traffic alignment and north Rio Piedras Station location
- Alternative 5 - PR-3 Busway with Rio Grande Loiza bridge southern alignment and north Rio Piedras Station location

Service options considered included alternative busway signal improvements, and alternative vehicle propulsion systems.

Figure 1: Conceptual BRT Alignments



2.1. Route Location

The planned route for the BRT primarily follows highway PR-3, also known as Ave. Regimiento 65 De Infanteria between Rio Piedras and Carolina.

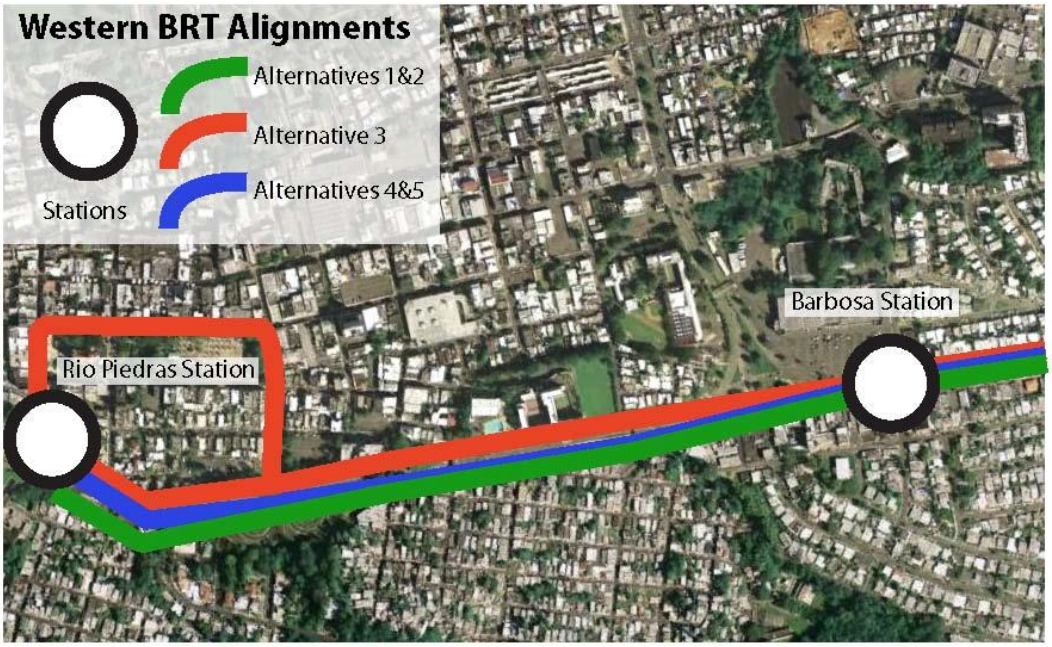
At the western end of the corridor, a station will be located within the Rio Piedras district, as close as possible to the Tren Urbano Station bearing the same name. There are three different locations under consideration:

South Rio Piedras Station – This station would be located on the south side of PR-3. Buses would access the station along a busway running approximately between Cll Marginal and PR-3. Transit riders would connect to the Rio Piedras Tren Urbano station by walking along the pedestrian bridge crossing over PR-3 and along Ave. Juan Ponce de Leon. This station location is incorporated into Alternatives 1 and 2.

Tren Urbano Rio Piedras Station – This station would be located at the existing bus stop across Ave. Juan Ponce de Leon from the Tren Urbano Rio Piedras station entrance. Buses would access the station using the existing roadways and operating in mixed-traffic. Transit riders would connect to the Rio Piedras Tren Urbano station by walking across the street to the station entrance. This station location is incorporated into Alternative 3.

North Rio Piedras Station – This station would be located on the north side of PR-3 in the existing transit station parking lot. Buses would access the station by crossing from the busway in the median of PR-3 to Ave. Juan Ponce de Leon before entering the station site. Transit riders would connect to the Rio Piedras Tren Urbano station by walking along Ave. Juan Ponce de Leon to the station entrance. This station location is incorporated into Alternatives 4 and 5.

Figure 2 – Alignment of Alternatives in Rio Piedras – Barbosa Station segment



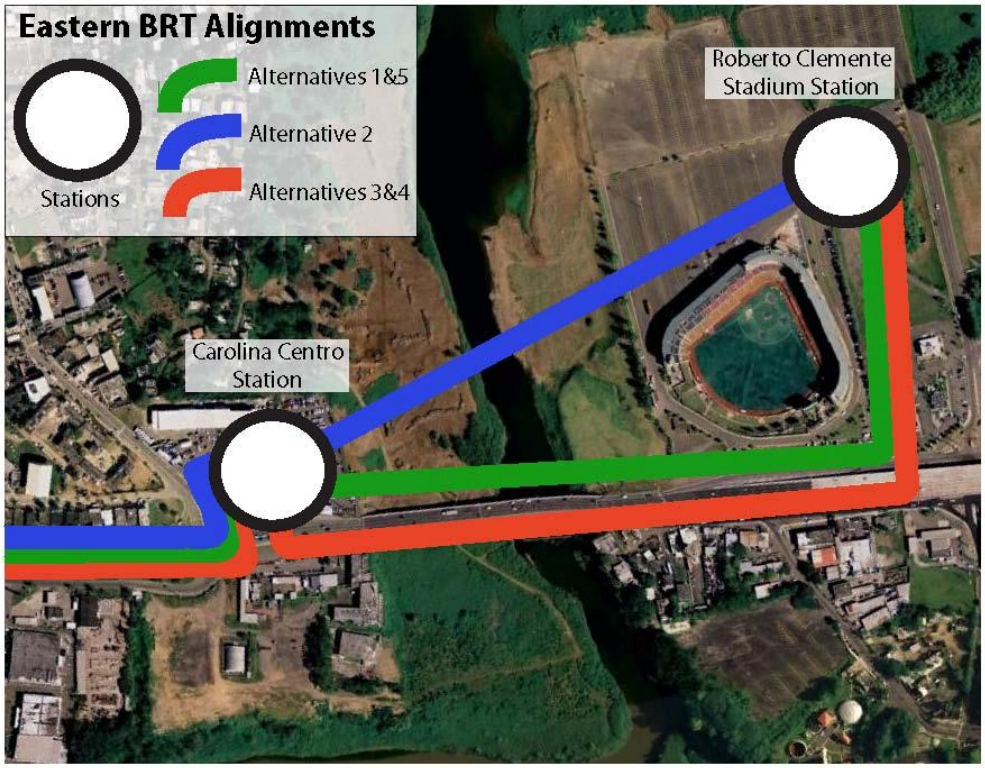
Once within the PR-3 corridor, the planned route will follow the highway for just under eight miles (12.8 km) to the intersection with PR-874 in the Carolina area. From here, buses will exit the median busway to access the Carolina Centro Station located in the northwest quadrant of the intersection. Between Carolina Centro and the terminal station at Roberto Clemente Walker Stadium there are three alternative routings under consideration.

Rio Grande Loiza Bridge southern alignment - this alternative utilizes an alignment that runs parallel to the existing PR-3 bridge. Buses would exit directly from Carolina Centro to the exclusive busway crossing over the river and running along the southerly side of the stadium before reaching the terminal station. This bridge alignment is incorporated into Alternatives 1 and 5.

Rio Grande Loiza Bridge northern alignment - this alternative utilizes an alignment that runs along a more northerly route running directly from Carolina Centro Station to the northerly side of the stadium, where the station entrance is located. This bridge alignment is incorporated into Alternative 2.

Rio Grande Loiza Bridge mixed-traffic alignment - In this alternative the buses run in mixed-traffic for much of the ¾ mile between Carolina Centro and Roberto Clemente Stations. After exiting Carolina Centro Station buses would turn left on PR-874 and again on to PR-3. After crossing over Rio Grande Loiza on the existing PR-3 bridge, the buses would access the station along a route that uses the existing off-ramp and intersection improvements to facilitate the movement of buses to the station access road. This bridge alignment is incorporated into Alternatives 3 and 4.

Figure 3 - Alternative Alignments between Carolina Centro and Roberto Clemente Stations



2.2. Mixed Traffic Operations

Some alternatives have been designed to minimize capital costs by eliminating the busway in certain segments. This includes operating the buses in mixed traffic at one or both ends of the line. This would mean that existing roadway volumes would be a factor in determining the speed, travel time and reliability of the system.

At the western terminus, mixed traffic roadways could be used to approach Rio Piedras Station. Cll Camelia Soto and PR-3 would be used to connect the station with the start of the busway just west of the PR-27 interchange. It was determined that a trip along this roadway takes an average of eight minutes westbound, and five minutes eastbound all day. These values have been used to estimate the affect of existing traffic on potential operation in mixed traffic. This mixed traffic segment is included in Alternative 3.

At the eastern terminus, mixed traffic roadways could be used to approach Roberto Clemente Walker Stadium Station from just east of the existing bridge over Rio Grande de Loiza. Existing on and off ramps from the highway would allow buses to access the stadium grounds and station on the northern side of the road. It was determined that a trip along this roadway takes an average of six minutes westbound, and five minutes eastbound all day. These values have been used to estimate the affect of existing traffic on potential operation in mixed traffic. This mixed traffic segment is included in Alternatives 3 and 4.

2.3. Busway Operations

In order to avoid heavy traffic along PR-3, the majority of the BRT route will operate in a separated busway located in the median of the highway. Currently, PR-3 is configured to have four to eight lanes with exclusive left turn lanes and signals. This segment of the highway includes intersections which are both grade separated and at-grade intersections with signalization or other traffic controls. Medians are currently present along most of this segment of the highway. The design for the busway includes 12 foot wide lanes with barriers between the busway and highway traffic. Grades along the busway are not designed in excess of 4.5%.

For all alternatives, the busway runs in the median of PR-3 between PR-27 and PR-874. The busway is extended to the terminal station in some alternatives. All of the station platforms are within the median busway, except for Rio Piedras, Carolina Centro and Roberto Clemente stations, which all fall outside this core busway area.

Along the busway route, speeds will generally be limited to 50 mph. Two locations will require slower speeds: the turns onto and off of PR-874, and a sharp curve in the busway as it navigates around the southern side of Roberto Clemente Walker Stadium. These two locations will have speeds limited to 15 mph.

Vehicles for the route were assumed to be 60 foot long New Flyer articulated buses. The buses will have dual-sided doorways to accommodate center and side platforms, and will have a diesel engine.

2.4. Proposed Stations

The Carolina BRT will have nine planned stations along the corridor, two terminal stations, and seven stations along the route. Of these seven, six are located within the median busway, and only one is located off to the side of the roadway. The nine stations are discussed below, from west to east:

- *Rio Piedras Station* – The western terminus, near the Rio Piedras Tren Urbano Station, will be located in one of three possible sites dependent on alternative advanced. See Section 2.1 for more information.
- *Barbosa Station* – This median station will be located just to the east of Cll Cabo Maximo Alomar, near Ave Barbosa.
- *Concordia Station* – This median station will be located just to the east of Expreso Trujilo Alto.
- *Berwind Station* – This median station will be located just to the east of Ave Monte Carlo
- *Escorial Station* – This median station will be located adjacent to the Plaza Escorial Shopping Center, just to the west of PR-8.
- *El Comandante Station* – This median station will be located near the intersection with PR-887.
- *Plaza Carolina Station* – This median station will be located just to the south of Plaza Carolina, adjacent to the interchange with PR-26.
- *Carolina Centro Station* – This station will be located on the northeast corner of the intersection of PR-3 and PR-874. It will require buses to leave the busway and access the station via PR-874.
- *Roberto Clemente Station* – The eastern terminus will be located in the current parking lot of Roberto Clemente Walker Stadium, to the northeast. This major parking lot will be utilized as a park-and-ride for passengers to access Tren Urbano and other destinations.

All median stations will be served by a center island platform, requiring buses to have left-side doors. The median stations will be accessed via pedestrian bridges over PR-3 from both sides of the roadway. Rio Piedras, Berwind, Escorial, Plaza Carolina, El Comandante, Carolina Centro and Roberto Clemente Stations will have parking lots constructed, or are located adjacent to existing parking lots for vehicle access. Barbosa and Concordia Stations will not provide parking. Rio Piedras, Carolina Centro and Roberto Clemente Stations will also provide for easy interface with existing local bus routes via shared platforms and station buildings.

2.5. Busway Intersections and Signal Priority

There are over 20 existing PR-3 intersections which will remain at-grade and will necessitate busway intersection improvements. The plans call for treating these busway intersections a number of different ways, including closure, while there are some existing intersections that will be grade separated:

- 17 intersections will remain open and be crossed at-grade. Currently, 16 of these have currently have traffic signals. while the only unsignalized one, Cll 11, will be signalized for the project.
- Two currently unsignalized intersections will be closed, Cll 7-A and Cll Ferrara.

- Two intersections will be bridged over with an elevated structure to avoid any traffic induced delay, PR-887 and Cll Parque De Bombas.
- Two intersections along the western segment of the corridor will be either bridged over with a busway structure, or used as part of a mixed-traffic alternative for the western terminus: PR-27 and Cll Camelia Soto.
- PR-874 will be used to access Carolina Centro Station from the west. Buses will need to cross the westbound lanes to access the station on the north side of the roadway. The roadway itself will be used for 150 meters to access the station. Westbound buses will need to also cross PR-874 itself to take a left out of Carolina Centro Station.
- Alternatives that include mixed traffic segments at either terminus will require further investigation into signal priority opportunities.

The alignment includes approximately 20 intersections that buses will need to negotiate at-grade. At these intersections, a variety of signal priority techniques could be employed to aid the performance of the BRT system. Three such techniques have been evaluated:

- Option 1 would require a full stop at every intersection on the route, activating a green signal before it could proceed,
- Option 2 is a full signal preemption system, which allows buses to cross through the intersections by only slowing to 35 mph and not stopping, and
- Option 3 is a priority system which provides priority in the signal timing systems to buses so that their delay associated with red signals would be limited.

Additional information regarding an analysis of the three options is provided in Section 3.2 – Service Options Considered.

2.6. Existing Services

The proposed Carolina BRT would connect to a variety of existing transit services in the corridor. The most important of these would be the connection to Tren Urbano Rio Piedras Station at the west terminus of the corridor. This would allow a direct connection to San Juan's most utilized public transit system, providing service every 10 minutes to downtown San Juan and western suburbs.

Connections would also be created to bus routes operated by Autoridad Metropolitana de Autobuses (AMA). AMA runs 30 bus routes throughout the metropolitan San Juan area, and many are located in or near the proposed corridor. Potential connections along the core of the route could be made to:

- A6: Iturregui – Plaza Carolina – Plaza Escorial-Carolina
- B15: Río Piedras – Embalse San José – Hato Rey – Estación Sagrado Corazón
- B26: Río Piedras – Estación Río Piedras – Urb. Venus Gardens
- B40: Estación Piñero – Puente Teodoro Moscoso – Aeropuerto Luis Muñoz Marín – Isla Verde
- B41: Estación Piñero – Capetillo – Villa Prades – Campo Rico-Iturregui
- B42: Iturregui – Ave. Comandante – Sánchez Osorio – Plaza Carolina – Fidalgo Díaz – Ave. Calderón – Carolina
- B43: Iturregui – Vistamar – Carr. #190 – Fidalgo Díaz – Plaza Carolina – Sánchez Castaño

In addition, connections could be made at the Rio Piedras Tren Urbano Station to the following bus routes:

- M-I: Río Piedras – Hato Rey-Santurce – San Juan
- ME: Estación Sagrado Corazón – Ave. Muñoz Rivera – Centro de Convenciones – Terminal San Juan
- A3: Río Piedras – Estación Hato Rey – F.D. Roosevelt – San Patricio-Cataño
- B4: Río Piedras – Estación Universidad – Estación Centro Médico – Ave. San Patricio – San Patricio
- A9: Río Piedras – Ave. Barbosa – Ave. Borinquen – Estación Sagrado Corazón – Ave. Fernández Juncos – Parada 18 – San Juan
- C18: Río Piedras – Estación Universidad – Carr.176 – Ave. Lomas Verdes – El Señorial – Cupey Gardens
- B28: Río Piedras – Estación Universidad – Ave. Piñero – Ave. San Patricio – San Patricio
- B29: Río Piedras – Estación Universidad – Estación Cupey – Urb. College Park – Muñoz Rivera – Guaynabo
- C31: Río Piedras – Estación Universidad – Estación Cupey – Calle Paraná – PR1 – Ave. Las Cumbres – Ave. Emiliano Pol
- A52: Estación Centro Médico – Santiago Iglesias – Estación Martínez Nadal – Ave. Los Filtros – Bayamón

In addition to the bus routes operated by AMA, various municipal trolleys operate within individual communities. These often serve as a circulator around a specific municipal area, and are operated by the communities.

3. SERVICE PLAN

The first section of this chapter outlines the methodology used to estimate total trip time, including detail on running time, delay time, dwell time and pad. The inputs to this process are enumerated, and the analysis of different operational options is provided.

The second section provides the results of this process, showing the trip times by different alternatives and direction. Other service characteristics are identified that provide required parameters necessary for the development of operating and maintenance costs and ridership estimates.

3.1. Running Time Methodology

The Trip Time Tool used in developing the estimated BRT travel times uses a series of calculations, inputs and assumptions to make an estimate of the running time of a certain route. There are four main components of the trip time calculation: running time, dwell time, delay time and pad time. In the following sections, the inputs, assumptions and calculations of the San Juan - Carolina BRT trip time are discussed.

3.1.1. Inputs

One of the principal sources of data utilized to calculate running times are the engineering drawings of the alternatives that provide the characteristics of the proposed busway and station stops. Jacobs used these drawings to separate the route into a series of segments, bounded by changes in the route, such as station stops, roadway intersections, elevated structures or median intrusions. Each of these segments was measured and recorded.

For the two segments where buses would operate in mixed-traffic, estimated travel times were developed based on existing travel times[1]. The western segment would operate between Rio Piedras Station and Barbosa Station via PR-3, Ave Juan Ponce de Leon, Cll Arzuaga and Cll Camelia Soto. The eastern segment would operate between Carolina Centro Station and Roberto Clemente Station via PR-3 and stadium access roads. The running times differ by direction due to differences in routing and traffic, and are as follows:

- From Rio Piedras Station to Barbosa Station: 8 minutes
- From Barbosa Station to Rio Piedras Station: 5 minutes
- From Carolina Centro Station to Roberto Clemente Station: 6 minutes
- From Roberto Clemente Station to Carolina Centro Station: 5 minutes

Acceleration and deceleration characteristics for the proposed vehicle are included as an input for running time development. As part of the service definition, it was identified that 60-foot articulated buses, such as those made by New Flyer for Eugene, Oregon, will be used for the service. The buses will have dual-sided doorways to accommodate center and side platforms, and will have a diesel engine. In order to have accurate characteristics, Jacobs contacted New Flyer and obtained the acceleration and deceleration characteristics for the correct bus model, New Flyer D60LFR. Other options regarding vehicle propulsion systems were examined as identified in Section 3.2 – Service Options Considered.

Signal timing diagrams for each at-grade intersection within the proposed corridor were examined. Using the existing signal timing, Jacobs determined the average amount of signal wait time buses will experience when running through the corridor. This is a major factor in deciding the level of signal priority to be used.

3.1.2. Signal Priority

The recommended signal priority scenario is a 'green extension' system. This was identified after analysis of signal priority options. The analysis of these options in included in Section 3.2. Currently, signals along PR-3 generally operate in a three-phase arrangement: the first phase allows through and right turning traffic in both directions on PR-3 simultaneously. The second phase allows for protected left turns from PR-3 to side streets in both directions. Finally, side streets see green in the 3rd phase. Buses would see green signals during phase 1, but red during phases 2 and 3. According to data supplied by BYA, phase 1 is the dominant, or most likely phase at most intersections along the route.

With a 'green extension' system, buses which are approaching a green light could continue at their current speed to cross the intersection. Loop detectors in the roadway would extend the green time of the current phase to allow the bus to reach the intersection and cross, before moving to the next phase. If the bus approaches during a red phase, it will need to wait until the next green phase. No red phases will be truncated for the bus, meaning that buses could be waiting for the entire red phase to clear. At certain intersections, the bus would always come to a stop and loop detectors would signal the need for a protected bus turning phase. These locations would include:

- turns in and out of the busway at Ave. Juan Ponce de Leon in Alternative 4, and;
- turns onto and off of PR-874 at Carolina Centro Station in all alternatives.

[1] Estimated mixed-traffic travel times were developed by BYA for Jacobs.

This level of signal priority allows for smooth operation of the system without significantly affecting traffic on adjacent or intersecting roadways.

3.1.3. Running Time Calculation

The Trip Time Tool uses acceleration and deceleration characteristics of a vehicle to determine the speed by which it will be able to travel between two points. It compares the maximum speed of the prior and following segments, determining what the maximum possible speed for the vehicle to reach is, and uses that as a basis for determining how long the segment takes. This is an iterative process that maximizes the speed within each segment for the entire route, while adhering to speed limits and stop locations.

For the San Juan-Carolina BRT, three different running times have been calculated as a way to identify the impact of various signal priority schemes on running times. The first running time calculated assumes that the bus will need to stop at every intersection before proceeding, assuming conservative rules of bus operations. This has been termed the "slow" scheme. The second running time assumes that the bus will be able to proceed at speed through every intersection (at 35 mph), assuming full signal pre-emption. This has been termed the "fast" scheme. These two running times represent the upper and lower bounds of any considered signal priority system. Additional detail is provided later in this memorandum regarding the results of those signal priority schemes.

The prescribed signal priority system for the San Juan-Carolina BRT will be 'green extension'. In this scenario, buses will be able to proceed at speed across intersections where the driver sees a green light ahead, but need to stop and wait where a red light is showing. This means that some percentage of time, the bus will be able to proceed without a wait, while sometimes it will need to wait. To calculate this running time, the individual timing of each signal was used. By looking at the signal timing chart, Jacobs was able to determine how often a bus would need to stop for a light. This percentage was used in a weighted average of the two running times ('slow' and 'fast'), resulting in an average speed through every intersection (the 'green extension' model). This speed was fed back into the Tool, and the Tool was able to give a resulting running time that reflects the optimum level of signal priority that is likely to balance transit operations and traffic impacts.

$$GreenExtensionSpeed = \frac{(green\% * FastSpeed) + (red\% * SlowSpeed)}{100}$$

3.1.4. Delay Time

Since the San Juan-Carolina BRT will need to stop at roadway intersections that have a red light, there will be some level of traffic signal delay, or waiting time. This will be proportional to the likelihood the bus will need to stop, and the length of time it will need to stop for. At each intersection, the total amount of red signal time the bus could see is divided by two, to give the average amount of red signal time at each intersection. This value is multiplied by the percent chance of a red signal. The delay time is added to the running time for each segment where it is necessary.

$$Delay = red\% * \left(\frac{redtime}{2} \right)$$

3.1.5. Dwell Time

Dwell time is the amount of time spent at stations to allow for passengers to board and depart. It is based on the number of passengers exiting or entering the vehicle, the number of doors, the level of the doors, and the fare collection system.

The San Juan-Carolina BRT is assumed to have either 2 or 3 doors per vehicle, an off-board fare collection system, and level boarding. All of these factors lead towards a fairly short dwell time. The Trip Time Tool uses 30 seconds as a default dwell time, which is a common industry standard across all station types.

3.1.6. Pad Time

Pad time is a buffer that allows for some variability in the running time of transit vehicles. Throughout the course of a day, some buses will arrive slightly early, and some slightly late. An addition of pad time gives some leeway to the operators. For the San Juan-Carolina BRT, a 7% pad time, which is an industry standard, has been added to each individual segment along the line. This percent is applied to only the running times of each segment.

3.2. Additional Service Options Considered

3.2.1.Signal Priority Options

In order to determine the correct level of signal priority and bus speeds to use for the recommended option, Jacobs performed an analysis of the characteristics of different signal systems and their impact on the bus travel times of the San Juan-Carolina corridor. Three signal priority options were considered that each require a different set of infrastructure and include different assumptions regarding bus operating rules. The option recommended is one that appears to balance the benefits to the travel speed of the buses and impacts to the flow of vehicles at each intersection.

The first signal priority option tested was a “slow” option, which requires each bus to slow to a full stop at every busway intersection and proceed only if there is a green light. This option represents a scenario where the signal timing of each intersection will remain as it currently exists and will be interrupted each time a bus arrives at the intersection. This represents a very conservative transit operating rule that would assume general traffic making turning moves will always be in the way of proceeding buses and that buses must wait at each intersection for traffic to be clear before proceeding. This is a signal priority approach that has been used in Florida due to the number of accidents that have occurred at busway intersections.

A ‘fast’ option was also tested, which never requires the buses to stop at busway intersections. Every light is assumed to be in the green phase so that the bus can proceed though the intersection at 35 mile per hour. This option represents a full signal pre-emption scenario where the approaching bus immediately interrupts the signal timing and allows for the bus to proceed through. This is an aggressive approach that will likely result in some significant impacts to general traffic.

These two models were then compared to the third approach, which is called a ‘green extension’ option. The green extension approach includes a system in which buses that are approaching an intersection that has a green light could continue at their current speed through the intersection. Loop detectors in the roadway would signal that the bus is approaching and therefore extend the

green time of the current phase before moving to the next phase. If the bus approaches during a red phase, it will need to wait until the next green phase. No red phases will be truncated for the bus, meaning that buses could be waiting for the entire red phase to clear. This option provides some travel time benefits to the buses but is not likely to dramatically impact the operation of the existing intersection. In addition to the signal improvements that will enable the green extension, signal phases may be necessary to eliminate the conflict of left turning vehicles and the through movement of the buses.

The percent changes of each respective slower and faster model are consistent both within each alternative, and between different alternatives. This represents the total range of possible travel times for the BRT service.

Table 1:
Signal Priority Analysis

			Trip Time	Difference	% Change
Alt 1	EB	Slow	0:30:54	0:04:07	-15%
		Fast	0:19:45	0:07:03	26%
		Green Ext	0:26:48		
	WB	Slow	0:30:29	0:03:57	-15%
		Fast	0:19:57	0:06:34	25%
		Green Ext	0:26:31		
Alt 2	EB	Slow	0:30:43	0:04:07	-15%
		Fast	0:19:34	0:07:03	26%
		Green Ext	0:26:37		
	WB	Slow	0:30:17	0:04:13	-16%
		Fast	0:19:46	0:06:19	24%
		Green Ext	0:26:05		
Alt 3	EB	Slow	0:41:53	0:03:54	-10%
		Fast	0:30:31	0:07:28	20%
		Green Ext	0:37:59		
	WB	Slow	0:37:13	0:03:49	-11%
		Fast	0:26:44	0:06:40	20%
		Green Ext	0:33:24		
Alt 4	EB	Slow	0:36:57	0:04:08	-13%
		Fast	0:23:32	0:09:17	28%
		Green Ext	0:32:48		
	WB	Slow	0:35:23	0:04:02	-13%
		Fast	0:18:46	0:12:35	40%
		Green Ext	0:31:21		
Alt 5	EB	Slow	0:38:17	0:04:09	-12%
		Fast	0:24:52	0:09:16	27%
		Green Ext	0:34:08		
	WB	Slow	0:36:26	0:03:54	-12%
		Fast	0:20:06	0:12:26	38%
		Green Ext	0:32:32		

3.2.2.Vehicle Type Analysis

Jacobs also performed a vehicle type analysis in regards to the propulsion system for vehicles that may be used, either diesel powered or diesel-electric hybrid. Hybrid vehicles have comparable power, and accelerate more quickly through higher speeds, but have a lower acceleration at low speeds, in comparison to diesel buses. The results of the vehicle type analysis are as follows:

Table 2:
Vehicle Analysis

		Trip Time	Difference	% Change
Alt 1	EB Diesel	0:26:48		
	EB Hybrid	0:25:36	0:01:12	4%
	WB Diesel	0:26:31		
	WB Hybrid	0:25:15	0:01:16	4%
Alt 2	EB Diesel	0:26:37		
	EB Hybrid	0:25:25	0:01:12	4%
	WB Diesel	0:26:05		
	WB Hybrid	0:24:51	0:01:14	4%
Alt 3	EB Diesel	0:37:59		
	EB Hybrid	0:37:02	0:00:56	3%
	WB Diesel	0:33:24		
	WB Hybrid	0:32:22	0:01:02	3%
Alt 4	EB Diesel	0:32:48		
	EB Hybrid	0:31:41	0:01:07	3%
	WB Diesel	0:31:21		
	WB Hybrid	0:30:08	0:01:13	3%
Alt 5	EB Diesel	0:34:08		
	EB Hybrid	0:32:25	0:01:43	5%
	WB Diesel	0:32:32		
	WB Hybrid	0:31:01	0:01:31	5%

In comparison with diesel vehicles, hybrid vehicles are able to complete the trip slightly faster. The difference in vehicle performance alone does not warrant the purchase of a more expensive hybrid powered vehicle. In fact, the results of the analysis indicate that the trip time and vehicle performance considerations should not be a major factor in the selection of a vehicle type since the trip time differences are not significant.

3.3. Running Time Results

Alternatives for the Carolina BRT operations were developed from five different combinations of the alignment alternatives developed for the eastern end and western end of the alignment. A total of five alternatives were developed to create estimated running times. The approximate routes and station locations for each alternative are included in Figure 1.

- Alternative 1 uses a fully separated right-of-way from Rio Piedras to Roberto Clemente. In crossing the Rio Grande de Loiza, it uses a bridge that runs parallel to PR-3

- Alternative 2 is identical to Alternative 1, with the exception of the Rio Grande de Loiza bridge, which is aligned to run between Carolina Centro Station and the north side of Roberto Clemente Stadium

- Alternative 3 operates in mixed traffic between Rio Piedras and Barbosa Stations, and between Carolina Centro and Roberto Clemente Stations. A separated busway is used between Barbosa and Carolina Centro Stations.

- Alternative 4 operates in mixed traffic only between Carolina Centro and Roberto Clemente Stations. A separated busway is used between the northerly Rio Piedras Station site and Carolina Centro Station.

- Alternative 5 is identical to Alternative 1, with the exception of the location of the Rio Piedras Station, which is located just to the north of PR-3 at the existing site of the Tren Urbano parking lot.

Because signal timings and traffic are different in each direction, eastbound and westbound times for the alternatives are not identical. The table below summarizes the estimated total trip time for each alternative in each direction, including running time, pad time, dwell time and delay time.

Table 3:

Total Trip Times

	Alt. 1	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**
Eastbound	26:48	26:37	37:59	32:48	27:59
Westbound	26:31	26:05	33:24	31:21	27:46

3.4. Other Trip Characteristics

To complete the service planning process, the trip time is used to calculate a series of other factors vital in determining the overall system schedule, ridership projection and operating and maintenance costs. For each alternative, those characteristics are shown in the table below, which include:

- Trip time (one way and round trip) – described above,
- Service Headway – time between successive trips leaving the terminals,
- Vehicle Cycle time – the round trip time plus a margin for recovery at both terminals,
- Hours of Service – definition of peak and off-peak times, and
- Vehicle Fleet Requirements – how many vehicles are needed to operate the service

In order to complete the service planning process, the trip time is used to calculate a series of other factors vital in determining the overall system schedule, ridership projection and operating and maintenance costs. For each alternative, those characteristics are shown in the table below. These characteristics include:

Table 4:

Service Plan Characteristics

	Alt. 1	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt 5**
Eastbound Trip Time	0:26:48	0:26:37	0:37:59	0:32:48	00:27:59
Westbound Trip Time	0:26:31	0:26:05	0:33:24	0:31:21	00:27:46
Roundtrip Time	0:53:19	0:52:41	1:11:23	1:04:09	00:55:46
Min. Recovery Time	0:10:00	0:10:00	0:10:00	0:10:00	00:10:00
Round Trip Time	1:03:19	1:02:41	1:21:23	1:14:09	01:05:46
Total Cycle Time	1:05:00	1:05:00	1:25:00	1:15:00	01:10:00
AM Peak Hours	6-9 AM	6-9 AM	6-9 AM	6-9 AM	6-9 AM
PM Peak Hours	4-7 PM	4-7 PM	4-7 PM	4-7 PM	4-7 PM
Span of Service	6AM – 11PM	6AM – 11PM	6AM – 11PM	6AM – 11PM	6AM – 11PM
Peak Headway	5	5	5	5	5
Off-Peak Frequency	15	15	15	15	15
Peak Vehicles	13	13	17	15	14
Spare Ratio	20%	20%	20%	20%	20%
Total Fleet Size	16	16	21	18	17

Based on the ridership estimates, it appears that the capacity of the system as currently defined is sufficient but will need to be carefully considered as planning and design is advanced. Additional information regarding passenger volume differences over the course of the day will determine the extent of modifications necessary, if any, to the service plan. Plan changes may include increasing headways during peak periods in order to accommodate demand.

4. VEHICLE STORAGE & MAINTENANCE FACILITY

This chapter presents the estimated requirements for a vehicle storage and maintenance facility for the BRT fleet. The requirements are based on the typical needs for a bus fleet the size anticipated for the San Juan - Carolina BRT service. This chapter includes a description of the functions, sizes and preferred configuration attributes of a vehicle storage and maintenance facility.

4.1. Operator Welfare Facilities

Operator welfare facilities for the BRT operations are anticipated to include all the amenities necessary for operator activities, plus the administration and supervisory personnel needed to oversee the operations functions. Anticipated amenities for bus operators include showers, lockers, canteen/lunchroom, and a "quiet room:" for operator rest between shifts. In addition to the operator amenities, the facility is anticipated to include space for operator training, administrators, supervisory personnel and dispatchers.

Based on a fleet of 24 buses it is anticipated that the size of the Operator Welfare/Transportation Administration Building would need to be approximately 2,000- 3,000 square feet. In addition to the building it is anticipated that a minimum of 35 spaces would be included for employee parking. This parking would be for the operations, administration and maintenance personnel. This is an order of magnitude estimate of space required based on typical requirements. A more detailed space requirements study will be necessary as more detailed information is available regarding space programming requirements.

4.2. Maintenance and Storage Facilities

Maintenance and storage facilities are the locations where the bus fleet is stored overnight and during periods when not in operation and provides space and facilities for bus cleaning, fueling and repair. Optimally the facility is located near the end of the line to minimize non-revenue mileage for travel between the BRT route and the facility. The major functions at the facility include the following:

Fuel/Wash Lanes: This area will used for the daily servicing of the BRT vehicles. This includes fueling, fluid filling/dispensing, and interior and exterior cleaning. Depending on the fare collection system, this area will also be used for cash removal or fare data downloads. The area should be arranged so that the buses can enter the fuel/wash lanes as they enter the facility. This will allow the buses to be serviced before going to storage. It is estimated that the fuel and wash facilities should be approximately 20 feet wide and 80 feet long each. This will provide sufficient space to work around the 10 foot by 60 foot buses.

Maintenance Facility: A maintenance facility will be used for routine maintenance and inspection. For the San Juan-Carolina Bus Fleet it is anticipated that it will need to include one bay for inspection, one bay for routine maintenance, and one bay for heavy maintenance, such as engine/transmission rebuilds or major body work. In addition to the maintenance bays a support building will need to be located nearby for the storage of materials, such as tires, batteries, engine parts, etc. The support building will also be used to house workshops for work on bus components, such as brakes, body parts or general repairs that can be done off of the vehicle. It is estimated that the support building will need to be approximately 4,000 to 5,000 square feet.

Bus Storage: Parking spaces are required for each of the buses in the fleet for overnight or mid-day storage. Optimally the spaces would be arranged in a manner that does not require buses to be stacked bumper to bumper, or which would require buses to back out of a space. Based on the anticipated fleet size of between 16 and 21 buses for the San Juan-Carolina fleet, a facility that can accommodate 19 to 24 buses should be developed in order to provide space for any long-term storage of vehicles that may be necessary.

5. OPERATIONS AND MAINTENANCE COSTS

This chapter presents estimates of the annual costs to operate the San Juan Carolina BRT service. These costs include transportation (vehicle operation, fare inspection, dispatching and fuel costs), maintenance of equipment, station maintenance and upkeep, maintenance of way, and administration.

5.1. Estimating Transportation Expenses

Transportation costs include the direct costs for service including bus operators, supervisors, dispatching, and fuel. Although only weekday service schedules were developed, the costs for weekend service were estimated based upon a 16 hour service day each Saturday, Sunday, and holiday. The following was assumed for transportation costs[2]:

- Each bus operator would cost a fully loaded rate of $25.79. Overtime is charged at 1.5 times their hourly unloaded hourly rate ($17.00), and is $25.50, unloaded.
- Each operator has an average weekday productivity of 6.9 hours.
- Spare board employees are operators who have no regular assignments. It is used to cover assignments that cannot be filled due to vacation, sick leave, training, or other reasons. Assignments are made on a rotating basis, with operators who have worked most recently being placed at the bottom of the list, to progress upward as assignments are filled (subject to certain seniority rights). The spare board needs to have enough employees to cover up to ⅓ of the total required operators at any given time.
- It is anticipated that the operators will have approximately 10% overtime per year.
- Four full-time field supervisors (three Assistant Supervisors and one Chief Supervisor) would be responsible for all aspects of the BRT service, providing full coverage for daily operations, seven days a week, 365 days per year. Each Assistant Supervisor would cost a fully burdened rate of $35.20 and the Chief Supervisor is estimated to cost a fully burdened rate of $41.07. No overtime is anticipated.
- Six dispatchers would be required for service, two dispatchers per shift, two shifts per day, and two "spare board" dispatchers. Each dispatcher would cost a fully loaded rate of $28.60. Overtime is charged at 1.5 times their hourly unloaded hourly rate ($19.42), and is $29.13, unloaded.
- It is anticipated that the dispatchers will have approximately 10% overtime per year.
- Six roving fare inspectors would work the route ensuring that passengers have purchased a valid ticket. There will be two inspectors per shift, two shifts per day, and two "spare board" fare inspectors. Fare Inspectors would cost a fully loaded rate of $21.12. No overtime is assumed for fare inspection.
- No. 2 Diesel fuel costs are $2.27 per gallon[3].
- A New Flyer 60' articulated hybrid bus has a fuel consumption rate of 2.65 miles per gallon.[4]
- There are 260 days of weekday service days per year, with 116 roundtrips per weekday and 105 days of weekend and holiday service per year, with 64 roundtrips per weekend day.

[2] Assumptions are consistent with, and derived from the following: Jacobs Engineering Group. (2008). Operations *and Maintenance Plan for Tranvia de Carolina*. Prepared for Behar, Ybarra & Associates (BYA).

3 United States Department of Energy. Cost for No. 2 Diesel. Retrieved: May 19, 2010. Available: http://tonto.eia.doe.gov/dnav/pet/pet_pri_dist_a_EPD2DXL0_PCS_cpgal_m.htm, March 2010, Lower Atlantic States

4 Chicago Transit Authority. (April 10, 2009). CTA Uses Stimulus Funds to Purchase Articulated Hybrid Buses. Retrieved: August 20, 2010. Available: http://www.transitchicago.com/news/default.aspx?ArticleId=2318

A summary of total Transportation Staff requirements is shown below in Table 5.

Table 5:
Transportation Staffing Requirements

Staff Position	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Operators	23	23	30	26	24
Operator Spare Board	8	8	10	9	8
No. Assistant Supervisors	3	3	3	3	3
No. Chief Supervisors	1	1	1	1	1
Dispatchers	6	6	6	6	6
Fare Inspectors	6	6	6	6	6

A summary of transportation expenses costs is shown in Table 6.

Table 6:
Estimated Annual Transportation Expenses

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Category					
Operators	$ 1,783,560	$ 1,783,560	$ 2,329,302	$ 2,052,844	$ 1,918,202
Supervision	$ 305,104	$ 305,104	$ 305,104	$ 305,104	$ 305,104
Dispatching	$ 393,294	$ 393,294	$ 393,294	$ 393,294	$ 393,294
Fare Inspection	$ 263,610	$ 263,610	$ 263,610	$ 263,610	$ 263,610
Fuel	$ 517,626	$ 517,626	$ 521,126	$ 481,360	$ 482,649
Transportation Subtotal	***$ 3,263,194***	***$ 3,263,194***	***$ 3,812,436***	***$ 3,496,212***	***$ 3,362,859***

5.2. Estimating Mechanical Expenses

The mechanical costs associated with bus maintenance include labor and materials for vehicle maintenance. Using 2008 National Transportation Database (NTD) data for the San Juan Metropolitan Bus Authority (NTD ID No.: 4086) mechanical expenses for bus maintenance can be broken down into labor and material costs per vehicle. These costs are:

- The labor costs associated with maintaining a single bus are $41,138 per year.
- The material costs associated with maintaining a single bus are $10,662 per year.

A summary of fleet requirements for each alternative is shown in Table 7.

Table 7: **Fleet Requirements**					
	Alt 1	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**
Fleet Requirements	16	16	21	18	17

A summary of the annual maintenance of equipment costs is shown in Table 8.

Table 8: **Estimated Annual Maintenance of Equipment Costs**					
Category	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**
Labor	$ 658,203	$ 658,203	$ 863,891	$ 740,478	$ 699,341
Materials	$ 170,593	$ 170,593	$ 223,903	$ 191,917	$ 181,255
Maintenance of Equipment Subtotal	***$ 828,796***	***$ 828,796***	***$ 1,087,794***	***$ 932,395***	***$ 880,595***

5.3. Estimating Facilities Costs

Engineering (infrastructure) maintenance costs includes station maintenance, cleaning, and lighting. It also includes non-lighting electricity, other site utilities, policing, and other such concerns. An annual stipend of $34,145 per station was assigned to cover these costs[5]. Since the number of Ticket Vending Machines (TVM) in each station varies (a terminal station will have four TVMs whereas a through station will have two TVMs), the cost of maintaining and servicing TVMs is calculated separately. An annual allowance of $4,478 per TVM was allocated for their upkeep[6].

For all four alternatives, there are nine BRT stations along the route, and 22 TVMs to maintain. A summary of the facilities costs are shown in Table 9.

Table 9: **Estimated Annual Facilities Expenses**					
	Alt 1	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**
Stations	$ 307,306	$ 307,306	$ 307,306	$ 307,306	$ 307,306
TVMs	$ 98,515	$ 98,515	$ 98,515	$ 98,515	$ 98,515
Facilities Subtotal	***$ 405,821***	***$ 405,821***	***$ 405,821***	***$ 405,821***	***$ 405,821***

5 BYA Tranvia de Carolina report. Derived from pp. 19 & pp. 161.

6 Ibid.

5.4. Estimating Maintenance of Way (MOW)

Maintenance of Way costs include the everyday direct costs for inspection and maintenance of the infrastructure, including labor and materials. There are five types of rights-of-way (ROW) that the San Juan Carolina BRT service would use:

- Separated ROW,
- Mixed Traffic,
- Priority lane,
- Elevated ROW, and
- Transit Signal Priority Intersections.

In locations where the route would travel in mixed traffic or in a priority lane adjacent to traffic, there are no MOW costs since the road will be maintained by the municipal, territorial or federal authorities for public use. Costs associated with travel over a dedicated ROW for BRT use will require maintenance expenditures. Costs from Florida's 2007 Annual Highway Maintenance Costs were used as a model for determining an estimate of annual maintenance costs. This cost was adjusted to account for the difference between Florida and Puerto Rican costs. See Table 10 below.

Additionally, many of the intersections will be upgraded to allow for bus Transit Signal Priority (TSP). Intersections that have a TSP system installed will need to be maintained and serviced throughout the year. This includes periodic system testing, component replacement and upgrades, other hardware upgrades, and other miscellaneous tasks. Based on a nationwide survey of TSP systems, Jacobs has estimated that the annual cost of TSP system maintenance is approximately $1,090 per intersection per direction of travel.

Table 10:
Maintenance of Way Costs

Item	Costs	Units	Source
Separated ROW	$ 7,060	Lane mile	Florida DOT[7]
Mixed Traffic	$ 0	Lane mile	JEG Assumption
Priority Lane	$ 0	Lane mile	JEG Assumption
Elevated ROW	$ 9,413	Lane mile	Florida DOT[8]
TSP Intersections	$ 1,090	per directional intersection	JEG[9]

[7] Derived from Florida Department of Transportation 2007 Annual Highway Maintenance Costs. Retrieved: May 19, 2010. Available: http://ops.fhwa.dot.gov/policyinformation/statistics/2007/xls/sf12.xls. Cost was adjusted from $2007 to $2010 using the United States Department of Labor, Bureau of Labor and Statistics of inflation rate of 5%. Resulting Cost was then adjusted to account for the cost difference between Puerto Rico and Florida at 18%.
[8] Ibid. Assumes a 40% contingency on top of the unit cost per lane mile.
[9] Jacobs Engineering Group. (July 8, 2010). Summary of Transit Signal Priority Memorandum, pp. 5.

A summary of the type of classification is shown below in Table 11.

Table 11:
Rights-of Way Types and Estimated Lengths

ROW Type	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Separated ROW	5.91	5.91	5.53	4.90	4.90
Mixed Traffic	1.51	1.51	2.04	1.90	1.93
Priority Lanes	0.00	0.00	0.00	0.00	0.00
Elevated ROW	0.53	0.53	0.38	0.60	0.60
Total	***7.95***	***7.95***	***7.95***	***7.40***	***7.43***

Table 12 shows a summary of the number of TSP intersections per alternative.

Table 12:
Transit Signal Priority Intersections

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
No. Intersections	41	41	41	37	37

5.5. Estimating Administrative Expenses

Administrative costs include the revenue collection and accounting, marketing, finance, personnel, training, safety, environmental compliance, and management. These costs are estimated at 22% of the transportation, mechanical, station, and MOW costs.[10]

5.6. Summary of Operating Expenses

A summary of estimated annual operating expenses is shown below in Table 13. As shown in this Table, the estimated annual operating costs range from $5.7 to $6.6 million per year.

[10] Derived from BYA Tranvia de Carolina Report, pp. 82.

Table 13:
Summary of Annual Operating Expenses[11]

Cost Category	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Transportation					
Operators	$ 1,780,000	$ 1,780,000	$ 2,330,000	$ 2,050,000	$ 1,920,000
Supervision	$ 310,000	$ 310,000	$ 310,000	$ 310,000	$ 310,000
Dispatching	$ 390,000	$ 390,000	$ 390,000	$ 390,000	$ 390,000
Fare Inspection	$ 260,000	$ 260,000	$ 260,000	$ 260,000	$ 260,000
Fuel	$ 520,000	$ 520,000	$ 520,000	$ 480,000	$ 480,000
Subtotal	*$ 3,260,000*	*$ 3,260,000*	*$ 3,810,000*	*$ 3,500,000*	*$ 3,360,000*
Facilities					
Stations	$ 310,000	$ 310,000	$ 310,000	$ 310,000	$ 310,000
TVMs	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
Subtotal	*$ 410,000*	*$ 410,000*	*$ 410,000*	*$ 410,000*	*$ 410,000*
Maintenance of Equipment					
Labor	$ 660,000	$ 660,000	$ 860,000	$ 740,000	$ 700,000
Materials	$ 170,000	$ 170,000	$ 220,000	$ 190,000	$ 180,000
Subtotal	*$ 830,000*	*$ 830,000*	*$ 1,090,000*	*$ 930,000*	*$ 880,000*
Maintenance of Way					
ROW	$ 90,000	$ 90,000	$ 90,000	$ 80,000	$ 80,000
TSP	$ 40,000	$ 40,000	$ 40,000	$ 40,000	$ 40,000
Subtotal	*$ 140,000*	*$ 140,000*	*$ 130,000*	*$ 120,000*	*$ 120,000*
Subtotal I	$ 4,640,000	$ 4,640,000	$ 5,440,000	$ 4,950,000	$ 4,770,000
Administration (22%)	$ 1,020,000	$ 1,020,000	$ 1,200,000	$ 1,090,000	$ 1,050,000
Estimated Annual O&M	***$ 5,660,000***	***$ 5,660,000***	***$ 6,630,000***	***$ 6,040,000***	***$ 5,820,000***

[11] Due to rounding, some values may not add properly

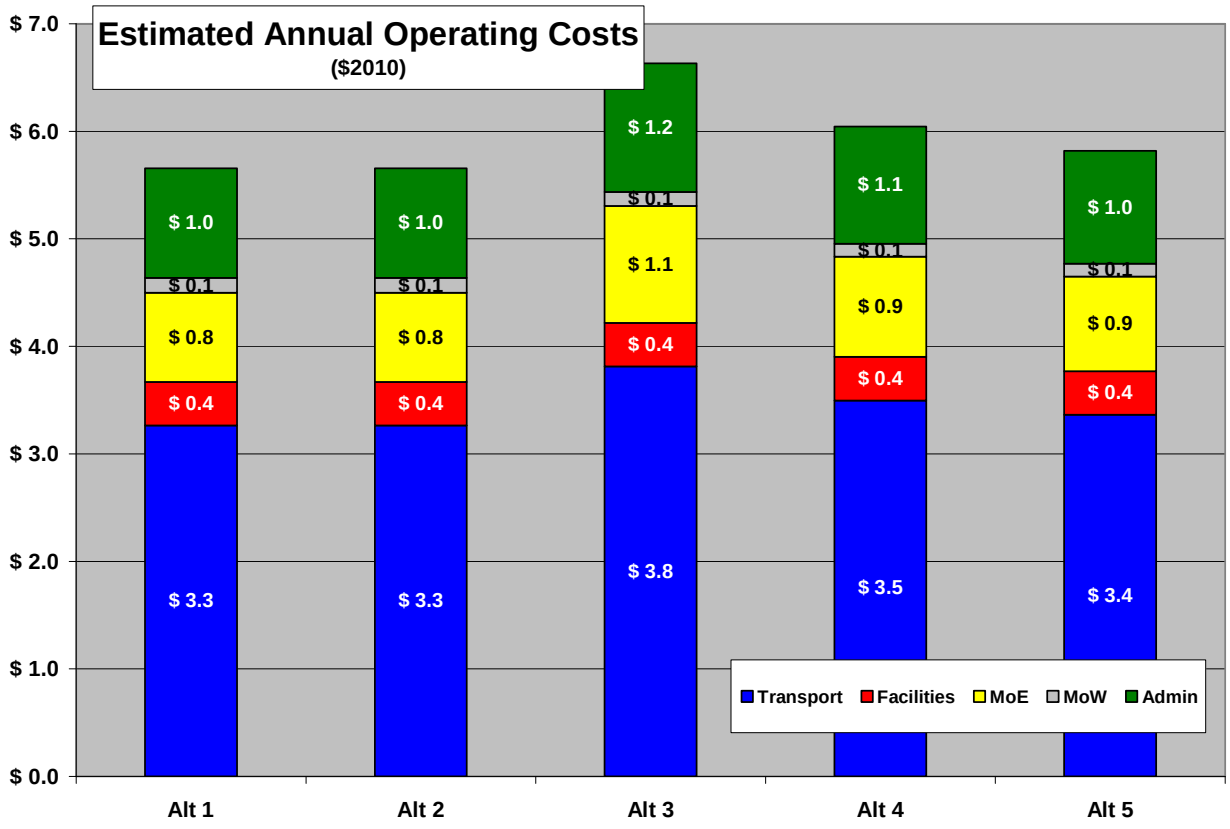


Figure 4: Estimated Annual Operating Costs

The least expensive options are Alternatives 1 and 2, estimated to be $5.7 million annually. This is primarily due to the smaller fleet size required to operate the service. Conversely, the most financially intensive option is Alternative 3, whose estimated annual cost is $6.6 million; this is due principally to the higher fleet requirement than the other alternatives.

6. APPENDIX A - SAMPLE SCHEDULES

Alternative 1, Eastbound, AM Peak (6AM-7AM)

Station	A	B	C	D	E	F	G	H	I	J	K	L	M
Rio Piedras	06:00	06:05	06:10	06:15	06:20	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00
Barbosa	06:03	06:08	06:13	06:18	06:23	06:28	06:33	06:38	06:43	06:48	06:53	06:58	07:03
Concordia	06:06	06:11	06:16	06:21	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06
Berwind	06:11	06:16	06:21	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06	07:11
Escorial	06:14	06:19	06:24	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04	07:09	07:14
El Comandante	06:16	06:21	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06	07:11	07:16
Plaza Carolina	06:20	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00	07:05	07:10	07:15	07:20
Carolina Centro	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06	07:11	07:16	07:21	07:26
Roberto Clemente	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12	07:17	07:22	07:27

Alternative 1, Westbound, AM Peak (6AM-7AM)

Station	H	I	J	K	L	M	A	B	C	D	E	F	G
Roberto Clemente	06:02	06:07	06:12	06:17	06:22	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02
Carolina Centro	06:04	06:09	06:14	06:19	06:24	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04
Plaza Carolina	06:10	06:15	06:20	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00	07:05	07:10
El Comandante	06:14	06:19	06:24	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04	07:09	07:14
Escorial	06:16	06:21	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06	07:11	07:16
Berwind	06:20	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00	07:05	07:10	07:15	07:20
Concordia	06:24	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04	07:09	07:14	07:19	07:24
Barbosa	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12	07:17	07:22	07:27
Rio Piedras	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04	07:09	07:14	07:19	07:24	07:29

Alternative 2, Eastbound, AM Peak (6AM-7AM)

Station	A	B	C	D	E	F	G	H	I	J	K	L	M
Rio Piedras	06:00	06:05	06:10	06:15	06:20	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00
Barbosa	06:03	06:08	06:13	06:18	06:23	06:28	06:33	06:38	06:43	06:48	06:53	06:58	07:03
Concordia	06:06	06:11	06:16	06:21	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06
Berwind	06:11	06:16	06:21	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06	07:11
Escorial	06:14	06:19	06:24	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04	07:09	07:14
El Comandante	06:16	06:21	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06	07:11	07:16
Plaza Carolina	06:20	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00	07:05	07:10	07:15	07:20
Carolina Centro	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06	07:11	07:16	07:21	07:26
Roberto Clemente	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12	07:17	07:22	07:27

Alternative 2, Westbound, AM Peak (6AM-7AM)

Station	H	I	J	K	L	M	A	B	C	D	E	F	G
Roberto Clemente	06:02	06:07	06:12	06:17	06:22	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02
Carolina Centro	06:04	06:09	06:14	06:19	06:24	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04
Plaza Carolina	06:10	06:15	06:20	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00	07:05	07:10
El Comandante	06:14	06:19	06:24	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04	07:09	07:14
Escorial	06:16	06:21	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06	07:11	07:16
Berwind	06:19	06:24	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04	07:09	07:14	07:19
Concordia	06:23	06:28	06:33	06:38	06:43	06:48	06:53	06:58	07:03	07:08	07:13	07:18	07:23
Barbosa	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06	07:11	07:16	07:21	07:26
Rio Piedras	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04	07:09	07:14	07:19	07:24	07:29

Alternative 3, Eastbound, AM Peak (6AM-7AM)

Station	A	B	C	D	E	F	G	H	I	J	K	L	M
Rio Piedras	06:00	06:05	06:10	06:15	06:20	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00
Barbosa	06:09	06:14	06:19	06:24	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04	07:09
Concordia	06:12	06:17	06:22	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12
Berwind	06:17	06:22	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12	07:17
Escorial	06:20	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00	07:05	07:10	07:15	07:20
El Comandante	06:23	06:28	06:33	06:38	06:43	06:48	06:53	06:58	07:03	07:08	07:13	07:18	07:23
Plaza Carolina	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12	07:17	07:22	07:27
Carolina Centro	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12	07:17	07:22	07:27	07:32
Roberto Clemente	06:38	06:43	06:48	06:53	06:58	07:03	07:08	07:13	07:18	07:23	07:28	07:33	07:38

Alternative 3, Westbound, AM Peak (6AM-7AM)

Station	J	K	L	M	N	O	P	Q	A	B	C	D	E
Roberto Clemente	06:05	06:10	06:15	06:20	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00	07:05
Carolina Centro	06:11	06:16	06:21	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06	07:11
Plaza Carolina	06:17	06:22	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12	07:17
El Comandante	06:21	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06	07:11	07:16	07:21
Escorial	06:23	06:28	06:33	06:38	06:43	06:48	06:53	06:58	07:03	07:08	07:13	07:18	07:23
Berwind	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12	07:17	07:22	07:27
Concordia	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06	07:11	07:16	07:21	07:26	07:31
Barbosa	06:34	06:39	06:44	06:49	06:54	06:59	07:04	07:09	07:14	07:19	07:24	07:29	07:34
Rio Piedras	06:39	06:44	06:49	06:54	06:59	07:04	07:09	07:14	07:19	07:24	07:29	07:34	07:39

Alternative 4, Eastbound, AM Peak (6AM-7AM)

Station	A	B	C	D	E	F	G	H	I	J	K	L	M
Rio Piedras	06:00	06:05	06:10	06:15	06:20	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00
Barbosa	06:04	06:09	06:14	06:19	06:24	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04
Concordia	06:07	06:12	06:17	06:22	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07
Berwind	06:12	06:17	06:22	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12
Escorial	06:15	06:20	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00	07:05	07:10	07:15
El Comandante	06:17	06:22	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12	07:17
Plaza Carolina	06:22	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12	07:17	07:22
Carolina Centro	06:27	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12	07:17	07:22	07:27
Roberto Clemente	06:33	06:38	06:43	06:48	06:53	06:58	07:03	07:08	07:13	07:18	07:23	07:28	07:33

Alternative 4, Westbound, AM Peak (6AM-7AM)

Station	I	J	K	L	M	N	O	A	B	C	D	E	F
Roberto Clemente	06:03	06:08	06:13	06:18	06:23	06:28	06:33	06:38	06:43	06:48	06:53	06:58	07:03
Carolina Centro	06:09	06:14	06:19	06:24	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04	07:09
Plaza Carolina	06:15	06:20	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00	07:05	07:10	07:15
El Comandante	06:19	06:24	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04	07:09	07:14	07:19
Escorial	06:21	06:26	06:31	06:36	06:41	06:46	06:51	06:56	07:01	07:06	07:11	07:16	07:21
Berwind	06:25	06:30	06:35	06:40	06:45	06:50	06:55	07:00	07:05	07:10	07:15	07:20	07:25
Concordia	06:29	06:34	06:39	06:44	06:49	06:54	06:59	07:04	07:09	07:14	07:19	07:24	07:29
Barbosa	06:32	06:37	06:42	06:47	06:52	06:57	07:02	07:07	07:12	07:17	07:22	07:27	07:32
Rio Piedras	06:35	06:40	06:45	06:50	06:55	07:00	07:05	07:10	07:15	07:20	07:25	07:30	07:35

Alternative 5, Eastbound, AM Peak (6AM-7AM)

Station	A	B	C	D	E	F	G	H	I	J	K	L	M	A
Rio Piedras	6:00	6:05	6:10	6:15	6:20	6:25	6:30	6:35	6:40	6:45	6:50	6:55	7:00	7:05
Barbosa	6:04	6:09	6:14	6:19	6:24	6:29	6:34	6:39	6:44	6:49	6:54	6:59	7:04	7:09
Concordia	6:07	6:12	6:17	6:22	6:27	6:32	6:37	6:42	6:47	6:52	6:57	7:02	7:07	7:12
Berwind	6:12	6:17	6:22	6:27	6:32	6:37	6:42	6:47	6:52	6:57	7:02	7:07	7:12	7:17
Escorial	6:15	6:20	6:25	6:30	6:35	6:40	6:45	6:50	6:55	7:00	7:05	7:10	7:15	7:20
El Comandante	6:17	6:22	6:27	6:32	6:37	6:42	6:47	6:52	6:57	7:02	7:07	7:12	7:17	7:22
Plaza Carolina	6:21	6:26	6:31	6:36	6:41	6:46	6:51	6:56	7:01	7:06	7:11	7:16	7:21	7:26
Carolina Centro	6:26	6:31	6:36	6:41	6:46	6:51	6:56	7:01	7:06	7:11	7:16	7:21	7:26	7:31
Roberto Clemente	6:27	6:32	6:37	6:42	6:47	6:52	6:57	7:02	7:07	7:12	7:17	7:22	7:27	7:32

Alternative 5, Westbound, AM Peak (6AM-7AM)

Station	H	I	J	K	L	M	A	B	C	D	E	F	G	H
Roberto Clemente	6:02	6:07	6:12	6:17	6:22	6:27	6:32	6:37	6:42	6:47	6:52	6:57	7:02	7:07
Carolina Centro	6:04	6:09	6:14	6:19	6:24	6:29	6:34	6:39	6:44	6:49	6:54	6:59	7:04	7:09
Plaza Carolina	6:10	6:15	6:20	6:25	6:30	6:35	6:40	6:45	6:50	6:55	7:00	7:05	7:10	7:15
El Comandante	6:14	6:19	6:24	6:29	6:34	6:39	6:44	6:49	6:54	6:59	7:04	7:09	7:14	7:19
Escorial	6:16	6:21	6:26	6:31	6:36	6:41	6:46	6:51	6:56	7:01	7:06	7:11	7:16	7:21
Berwind	6:20	6:25	6:30	6:35	6:40	6:45	6:50	6:55	7:00	7:05	7:10	7:15	7:20	7:25
Concordia	6:24	6:29	6:34	6:39	6:44	6:49	6:54	6:59	7:04	7:09	7:14	7:19	7:24	7:29
Barbosa	6:27	6:32	6:37	6:42	6:47	6:52	6:57	7:02	7:07	7:12	7:17	7:22	7:27	7:32
Rio Piedras	6:30	6:35	6:40	6:45	6:50	6:55	7:00	7:05	7:10	7:15	7:20	7:25	7:30	7:35